Development and Evaluation of the Locally Made Propeller Type Mistblower

Dr. Mongkol Kwangwaropas[1]

Narong Onkong[2]

A propeller type mistblower was designed and manufactured. The machine consisted of a 770 millimeters diameter propeller driven by the power take off of a tractor. It delivered 26,400 cubic meters of air per hour and has the outlet speed about 180 kilometers per hour. Spray liquid was injected at 30 bars pressure through hollow cone type nozzles which were located around the air outlet of the machine by a piston type pump. Power consumption of the machine was found to be 12.46 kilowatts and the effective forward travel speed was about 2.7 kilometers per hour. Upon spraying mango trees, it was shown that the density of spray particles was about 100 microns and consumed 3.12 liters per tree. Working speed in 6 meters row spacing mango orchard was about one hectare per hour.

Key Word : Mistblower

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[1] Associate professor, Agricultural Engineering Department Faculty of Engineering Kasetsart University, Thailand.

[2] Teacher, Agricultural Engineering Department

Introduction

Thailand is a prominent fruits production country. In order to obtain the high yield and good qualily of produced fruits, the excellence maintenance work for orchards during seasons is required. Orchard spraying is one of the most important maintenance work. In Thailand farmers mainly used hydraulic sprayers to spray insecticides and fungicides. Spraying 4-5 meters height mango trees may consumed spray liquid as high as 10-20 liters/trees. Uneven spray material in the canopies is also another problem and caused problems in pests control. Excessive spray material consumption is also another severe problems. This research aimed to design and manufacture the prototype orchard mistblower which suit for the local conditions and can be manufactured locally. Most mojor components were available at the local market.

Generally, there are two most important requirements for orchard spraying, ie;

1. Droplets size should be ranged between 50-100 microns.
2. Droplets density should be at least 50 droplets per square centimeter.

These requirements generally can be achieved by using a mistblower. Most hydraulic sprayers produce much bigger droplets; ie about 300-400 microns which is too large for orchard spraying. Usually the 300-400 micron droplets size is good for herbicide spraying and not for spraying orchards which is mainly infected by insects and funguses. The suitable droplet sizes for pest control are generally around 50-100 microns. Too small droplets cause problem in drifting and evaporate too fast in hot climate.

During the operation of a mistblower, fine droplets will be carried by strong air which was generated by a propeller type blower in to the crops' canopy. Fine droplets usually are captured by leaves in the inner and upper zone of the tree. Large droplets usually are captured at the outer zone of the canopy. If droplets are too large,

the air can carry them at less distance and they are not able to penetrate into the inner side of trees' canopies. Moreover, number of droplets per square centimeter is too small and can cause the pest control work becomes ineffective. Excessive run off is also another common problem in that case.

Literature Review

There are many factors affecting the performance of a mistblower.

1. Air capacity of a mistblower

Air capacity can be calculated by the following equation (Harden, 1992)

$$Q = H \times D \times 1000 \quad \text{- - - - - - - - - - - - -} \quad (1)$$

Where

Q = air capacity (cubic meter/hour)

H = height of tree (meter)

D = diameter of tree (meter)

The air capacity has to be large enough to be able to carry spray particles into the canopies:

2. Effect of Evaporation

Life time of water droplet in seconds depends on size of droplets and temperature difference between wet and dry bulbs. (Mathew, 1979.) Life time spray particles can be calculated by using this equation.

$$t = \frac{d^2}{80\Delta t} \quad \text{————————} \quad (2)$$

where t = life time of particle in seconds

d = droplet diamete (microns)

Δt = difference in C^{o} between wet and dry thermometer.

This indicates that spraying druing hot weather may results in too much evaporation of some fine droplets.

3. Appplication Rate

Application rate is varied as the height of tree as shown is table 1.

4. Droplet size

Before spraying, types and positions of target have to be known exactly. Droplet size has to be according with targets. Table 2 shows this relationship. (Mathew, 1979)

Classification of droplets are defined by droplets' volume median diameter as shown in table 3

Objective

The objective of this research is to design, manufacture and testing of a mistblower using a propeller fan. The knowledge in manufacturing this locally made mist blower will enable more appropriate technology to be used in fruits production of the country.

Materials and Methods

Procedures in this step were carried out accordingly as follows;

1. Design of apparatus

1.1 Selection of propellers' size can be done by using equation 1. The height of tree and diameter of canopy are approximately 5 meters, therefore $Q = 25{,}000\ m^3/hr$. According to this requirement the size of propeller was selected from propeller manufacturers' specification. The 770 milimeters diameter propeller driven at 1620 revolutions per minute was

the most suitable one. (From the specification, Q = 26,400 m^3/hr)

1.2 A horizontal plunger type pump which has 30 bar operating pressure at 40 liter/minute capacity was selected.

1.3 Hollow cone type nozzle with adjustable spray pattern was selected due to techincal fitness and also has low cost as well.

1.4 An increasing speed ratio 3:1 gear box was designed and manufactured. Power from the tractor is transmitted via this gearbax to drive the propeller at the recommended speed.

2. Manufacturing

Since the objective of the project is to design the robust and easy to construct prototype machine. Therefore the frame and chassis were made of steel as welded constructions. All major components were installed on the chassis; The headstock of the machine was fitted with category $\prod$ three points hitch. A 50 horsepower tractor was suitable for this machine. The propeller and the spray pump were driven by the PTO shaft of the tractor. The revolution of the propeller was increased three times from that of the PTO shaft by the gear box up to 1620 revolutions per minute. The spray pump delivered spray liquid to nozzles which were fixed around the circumference of the propeller. (figure 1 and picture 1, picture 2)

3. Working principle of the machine

The mistblower was mounted on a 50 horsepower tractor which was driven along a row of trees. During operation the pump sucked spray liquid from the container and delivered to nozzles via a pressure regulator. Spray material was injected through hollow cone nozzles which were located along the circumference of the air deflector. Air was sucked from the rear side of the machine by a propeller. The direction

of air stream was changed 90° by a wind deflecter and was delivered out radially. The air velocily along the outlet of deflector was about 180 kilometers per hour. Spray particles were sheared in to smaller size by the air and were carried into the foilage of the tree by volume of air. The recommened forward travel speed of the tractor was about 2-3 kilometers/hour. The operating pressure of the pump was about 30 bars and delivered about 25 liters/minute the spray liquid (much lesser than the maximum capacity of the pump) through 16 hollow cone nozzles. This machine is suitable for spraying 5-6 meters height trees. Each row of trees received spray particles from 8 nozzzles. There were 16 nozzles spraying both rows of trees at a time.

Experimentations

Two types of experiments were carried out; ie laboratory tests, and field tests.

1. Laboratory tests

1.1 Measuring air outlet speed at nozzles positions using air velocity measuring device to detect.

1.2 Measuring air pressure at the same positions as in 1.1

1.3 Measuring torque of PTO of a tractor during operating the machine.

1.4 Check spray material consumption during injecting through nozzles, using 30 bars operating pressure.

2. Field tests

Field tests were done in mango orchards at Kampangsane district. Spacing between rows was 6 meters. The height of trees were around 5-6 meters and diameter of canopies were about 4-5 meters. The following tests were carried out

2.1 Measuring forward travel working speed.

2.2 Measuring average time consuming during headland turnings

2.3 Measuring actual spray consumption in liters/tree

2.4 Measuring spray distribution and droplets size using fluorescent dye tracer technique and water sensitive paper (WSP) technique. Sample of droplets were collected at nine positions from each tree.

Tables

Table 1. Relationship between height of tree and application rate

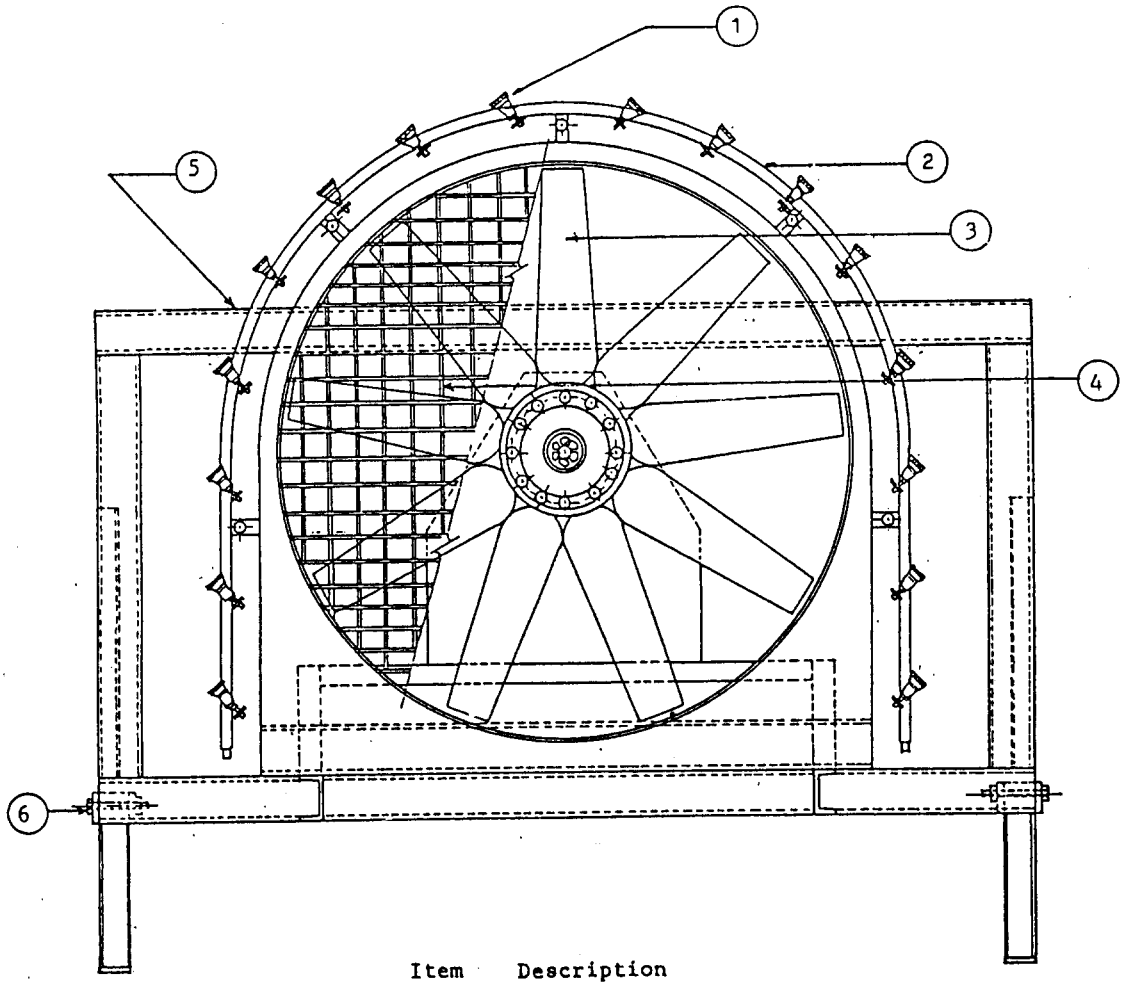
Height of tree (meters)	Application rate (liters/tree)
1 - 3	1 - 3
4 - 6	3 - 7
7 - 9	5 - 10
10 and over	7 - 10

Table 2. The relationship between targets and droplet sizes.

Target	Droplets' size (micron)
Flying insects	10 - 50
Insects on foilage	30 - 50
Foilage	40 - 100
Soil (and avoidance of drift)	250 - 500

Table 3. Classification of Droplets.

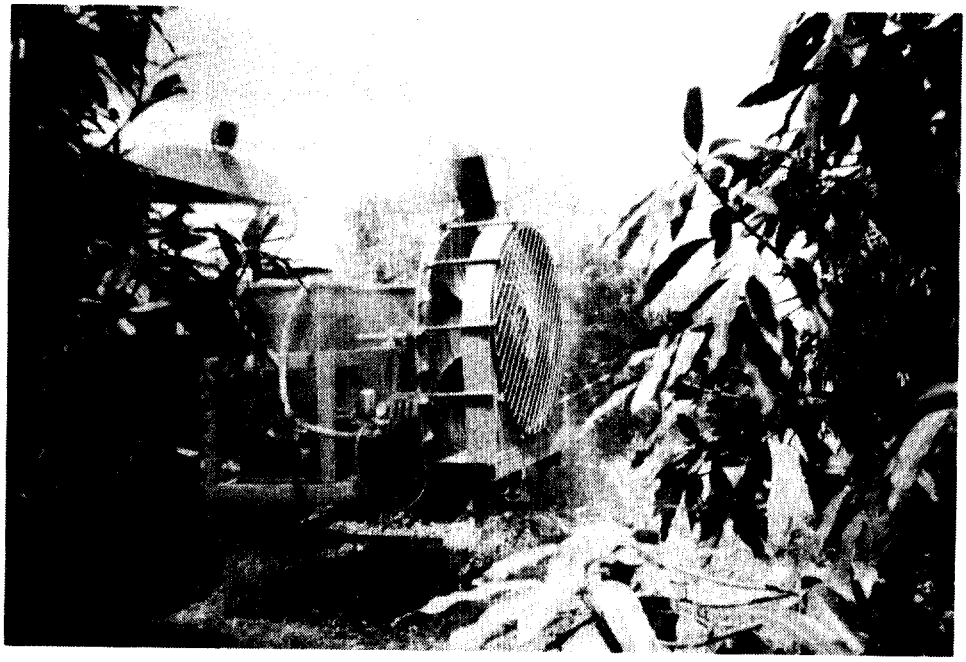
Volume median didmeter of droplet (micron)	Droplet size classification
< 50	Aerosole
50 - 100	Mist
101 - 200	Fine spray
201 - 400	Medium spray
> 400	Coarse spray



Item	Description
1.	Nozzle
2.	Nozzle pipe
3.	Propeller fan
4.	Protecting sieve
5.	Frame
6.	Tank mounting

Figure 1. Front view of the second set propeller type mist blower

Picture 1. The mistblower during operation



Picture 2. Another set of the mistblower which was also designed in this project during operation in mango orchard

Results and Discussion

Laboratory tests

Test results from the laboratory were as follows;

1. Air velocity at the outlet port was found to be 180 kilometers per hour when the PTO shaft speed of a tractor was 540 revolutions per minute.
2. Air pressure at the outlet port was found to be 1400 Pa
3. The torque of the PTO shaft was 27.5 kilograms-meter. This indicated that the power consumption was 12.46 kilowatts.
4. Spray liquid consumption was about 25 liters/tree

Field tests

Test results from the field were found and analyzed as follows;

1. Forward travel speed of the tractor (Using Yanmar TD5000) was 2.7 kilometers/hour.
2. Average head land turning was about 8.20 seconds.
3. spray liquids' consumption was about 3.12 liters/tree upon spraying six meters height mango trees. For a well prunning tree spraying one side is enough.
4. Volume median diameter and number median diameter were found to be 70.58 and 131.3 respectivity. Average droplet density of spray particles was about 271 droplets/square centimeter.

Conclusion

1. The 180 kilometers/hour air speed at the outlet port was sufficient to carry droplets into the trees canopies.
2. The power requirement of the machine was 12.46 kilowatts. A 40-50 horsepower tractor was suitable to opperate the machine because it was the mounted type.

This size of tractor had adequate stability during operation along rough terrians.

3. Spray liquid consumpion per tree was 3.12 liters/tree. Farmers ususlly used hydraulic sprayer to spray orchards and consumed 4-5 times of spray liquid more than using a mistblower.
4. Droplet size was with in 100 microns range. The top portion of trees has lesser spray particles than the middle and bottom portions. However it has enough particles to control most kinds of pests.
5. Ratio between volume median diameter and number median diameter was 0.54. This indicates that spray cloud has different sizes of particles.
6. Spraying along mango orchard which has row spacing 6 meters required about one hour to spray one hectare.
7. In conclusion, the machine meets requirements for spraying orchards.

Acknowledgement

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References

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